The MPIA-UKIRT-Project Software User's Guide

Draft

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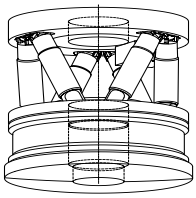

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Chapter 1: Introduction

1. Overview

Controlling and operating the MPIA-UKIRT-Project hardware was made as easy as possible. Four graphical user interfaces (GUI's) provide the user with almost everything that is necessary to operate and maintain the hardware.

Further maintenance commands and additional information is provided through the VME/ VxWorks console.

The three PI electronics boxes, Bottom End Controller (**bec**), Mirror Control Unit (**mcu**) and Hexapod Controller (**hexc**) also have serial RS232 ports that allow stand-alone operation and maintenance.

2. First steps

The beginning

Switching on and login procedure

1. Switch on the Tip-tilt sensor controller (AstroCam 4201 electronics)
2. Switch on the Bottom End Controller
3. Switch on the Mirror Control Unit
4. Switch on the VME/VxWorks system which is connected with the hardware described above
5. Login to your UNIX workstation (for login/account information ask local staff)
6. Give `cd $WROOT` and then type `astroCam.tcl &` in any xterm window to open the main GUI

7. Type `bec` in any xterm window to open the **bec** GUI
8. Open the **mcu** and **aui** GUI's from the **Windows** menu of the **bec** GUI
9. Open a telnet connection to the VME/VxWorks system. During normal operation there is no information of interest in the **VxWorks console** window so it can be closed (iconized). Let this window open until you have finished **First initializations and operational checkouts**

First initializations and operational checkouts

AstroCam subsystem

Click the **Refresh CCD** button within the **Setup** area of the **astroCam.tcl** GUI. On the **VxWorks console** you should see now numbers from 1-13 indicating the different stages of a **hardware init (hwinit)** procedure running inside the AstroCam controller (transputer). The **System status** changes from **idle** to **busy** while the **Refresh CCD** procedure is being processed. The **Command status** changes from **ok** to **sending command** and, depending on the result, back to either **acceptTimeout**, **commandTimeout** or **ok**. If everything looks fine you can be sure that the communication between your workstation and the VME/VxWorks/EPICS system as well as the communication between the VME/VxWorks/EPICS system and the AstroCam controller (transputer link) are ok. If this basic test fails see chapter *What to do when ...* at the end of this manual.

Bottom End Controller subsystem

Move the mouse pointer inside the **becgui.dl** window, select axis **0** (all axes) and press the **Goto ref. mark** button. The **Moving** and **Seeking reference** indicators for all axes should switch from **off** to **on**. After some minutes all stages should be initialized (**Reference found** and **Target reached** on, **Current pos.** and **Target pos.** 0, all other indicators should be off). **Connection:ok** should be the standard connection status. **Connection: down** for a short period of time (approx. 1s) is nothing you should worry about. **Connection:down** for longer than 5s means that you **really** have no connection to the Bottom End Controller.

Mirror Control Unit subsystem

Move the mouse pointer inside the **mcugui.dl** window and press the **Initialise** button below the **Hexapod** label. You don't need to initialize the Hexapod if the field on the right side of the **Initialize** button is empty, e.g. there is no blinking **NOT READY** text. As with the other *.dl windows **Connection:ok** is mandatory otherwise you cannot communicate with the hardware. After having pressed the **Initialize** button the green light right to the **Position** button starts blinking and the blinking **NOT READY** appears whether it was already visible or not.

The three fields below the **Piezos** label should all be **on**. If one of these **Mirror** controls is **off** and you cannot switch them on by pressing the corresponding button on the left side there's a good chance that some of the required PZT voltages (see MPIC, PZT Power Supply) are out of their operational range. In this case press the **MCU** button below the **System reset** label. If the last action doesn't help try switching off and on again the **mcu electronics**.

Initialize (goto reference mark) the **Sky Shutter** by pressing the **Init** button below the **Sky Shutter** label. The following messages can appear on the right side of the **Close** button:

1. notRef. Sky Shutter is not referenced/initialized
2. ref.ing Sky Shutter is currently initializing
3. atRef. Sky Shutter is at reference mark

4. opening — Sky Shutter is currently opening
5. closing — Sky Shutter is currently closing
6. opened — Sky Shutter is open
7. closed — Sky Shutter is closed
8. atPlim — Sky Shutter is at its positive limit
9. atNlim — Sky Shutter is at its negative limit
10. motnErr — A motion error occurred
11. badPos. — Sky Shutter is neither in the **opened** nor in the **closed** area

Tip-tilt sensor check

Move the mouse pointer into the astroCam.tcl window, click on the **Full Frame** button and then on the **Acquisition** button. After approx. 10s a window appears on the screen displaying the just taken image. You can move the mouse pointer into the image window and the actual x and y coordinates as well as the pixel intensity are displayed inside the image window. The number displayed in the image window title area gives the actual **Zoom** factor, e.g. **Z=1**.

Don't forget to quit the image display program draw **with** q

*In order to continue working with the **astroCam.tcl** program you have to terminate the image display program (**draw**) by typing **q** (for **q**uit) inside the image display window!*

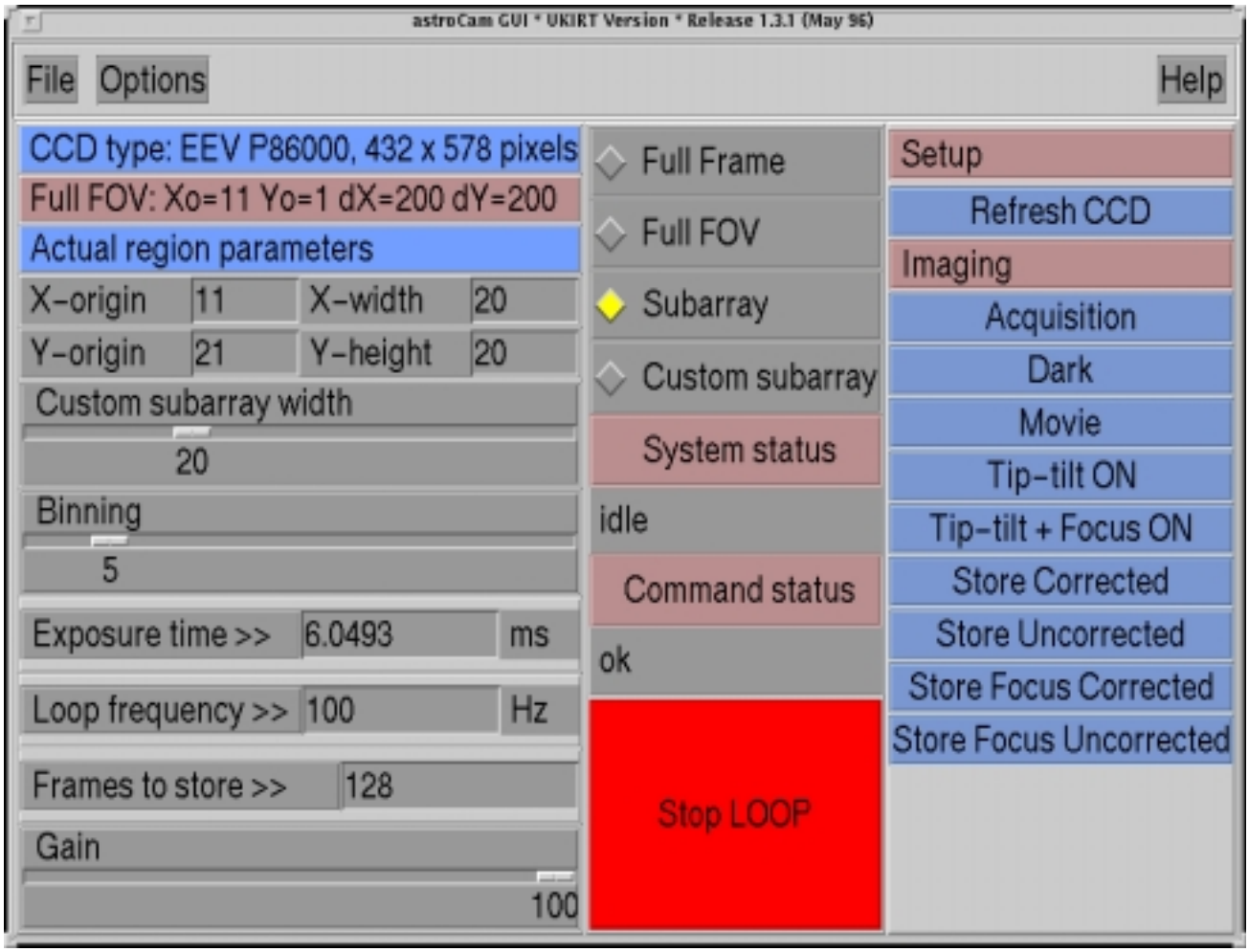
3. Nothing works ...

You can verify all start-up phases by carefully watching the VME console while it is booting. If you have to reboot the VME system do it by pressing the **RED** reset button on the CPU board. A soft reset (^X) doesn't work.

Parts of the VME start-up procedure are logged to files which you should inspect in case of problems.

If you cannot start the programs described above your login account is probably not setup properly, e.g. no **dm** command in your PATH or the TCL_LIBRARY and TK_LIBRARY environment variables point to the wrong TCL/TK version.

4. Snapshot of astroCam.tcl



Chapter 2: Tip-tilt correction

1. Adjusting and verifying scale factors

Tip-tilt correction can only work when the mapping between the Tip-tilt tracker (wavefront sensor) and the correction mirror (UKIRT's new secondary mirror) is correct. The Tip-tilt tracker's CCD geometry is 432 pixels (x) by 578 pixels (y). In order to correct an x or y displacement with the Secondary there are two variables `globals.dxscale` and `globals.dyscale` defined in aui.c. A third variable `globals.dzscale` is used for focus correction. Calibrating the system is easy:

1. Select **Full FOV** in **astroCam.tcl**, position a star (**Movie** mode) into the FOV center
2. Open the VME/VxWorks console window or use the "real" VxWorks console
3. Give `cd "work"` on the VxWorks console; substitute work by the directory name from where you have started **astroCam.tcl**, e.g. `echo $WROOT`
4. Type `sp mcuGetScale` on the VxWorks console
5. There are now 6 files in your UNIX directory $WROOT named `mcuGS00.fits`, `mcuGS01.fits`, `mcuGS02.fits`, `mcuGS03.fits`, `mcuGS04.fits` and `mcuGS05.fits` which correspond to the following Secondary tip-tilt positions in u (rad) and v (rad) coordinates:
    a. mcuGS00.fits -> 0, 0
    b. mcuGS01.fits -> -1E-4, -1E-4
    c. mcuGS02.fits -> +1E-4, -1E-4
    d. mcuGS03.fits -> -1E-4, +1E-4
    e. mcuGS04.fits -> +1E-4, +1E-4
    f. mcuGS05.fits -> 0, 0
6. Measure the center position of the star in each mirror position, e.g. use saoimage to load the fits images and write down the star's center coordinates

7. Calculate the difference between the first x-center coordinate and the second, between the second and the third and so forth. Sum up the five difference values and divide them by 4. Write this number <x> down. Repeat this procedure for the y-center coordinates but divide by 8 in order to calculate <y>.
8. Set globals.dxscale to 1.E-4/<y> and globals.dyscale to 1.E-4/<x>. Units are rad per CCD pixel. Remember that the x-axis on the CCD corresponds to the v-angle of the Secondary and the y-axis to the u-angle. Since <x> and <y> are pretty equal you can average them (<x>+<y>)/2 and set globals.dxscale and globals.dyscale equal 1.E-4 divided by (<x>+<y>)/2
9. Modify aui.c and compile it with `make` inside the **aui** directory
10. reboot the VME/VxWorks system (load the new aui routine)

2. Finding the tip-tilt guide star

Find your object with the science instrument. Start **Movie** in **Full FOV** mode and look for a “good” guide star. Move the guide star into the default subarray box by clicking on the guide star with the right mouse button (this works only when using **draw** as the default image display program, so don’t check **Use saoimage** in the **Options** menu). The default subarray is in the upper left corner. This is the optimal position for minimizing the readout time of the subarray.

If the star cannot be moved into that box, define a new subarray by clicking on the star with the left mouse button. Now, typing **q** inside the image window automatically invokes the **Custom subarray** mode in **astroCam.tcl**. The **Custom subarray width** can be adjusted by moving the slider. Using **Movie** again reads out exactly the newly defined subarray.

If the default subarray is fine clock on **Subarray** to define this part of the chip for the next imaging action.

3. Checking the readout parameters

To achieve a high loop frequency, the shutter of the CCD camera has to stay open and the camera is operated in a kind of frame transfer mode (see section Imaging modes in chapter **Glossary**). As the exposure is slightly different in the shutter modes like **Movie** and in the 'frame transfer modes' one has to take images with **Store Corrected** before starting the final T**ip-tilt ON** for unlimited correction.

The minimum shutter open time is about 25ms even though a smaller **Exposure time** was chosen.

Store Corrected (store a given number of images with tip-tilt correction on) or **Store Focus Corrected** (same as **Store Corrected** plus focus correction) reads out a limited number of frames that has to be specified in **Frames to store**. The >> indicates that by clicking on the text **Frames to store** a popup menu gives a selection of numbers that can be chosen. Once **Store Corrected** is started it cannot be stopped.

Be careful not to choose 1 second exposure time and 4096 frames: that keeps the system busy for more than an hour. Then, the only cure is resetting the VxWorks system.

One should aim at using a **Loop frequency** of at least 50 Hz, and to have an exposure time of at least the readout time. This can be checked by roughly estimating the cycle time as the reciprocal of the **Loop frequency**, and compare it to the **Exposure time**. At 50-70Hz, the exposure time is usually larger than the readout time.

As all images are stored when using **Store Corrected** the images are displayed at the end of the sequence. The display style is defined by **AstroCam**. They call it *tile image* because the images are displayed like tiles on the wall. Use the mouse to check whether the number of counts is all right and the stars look nice, *i.e.* round. As the tip-tilt correction is on in this mode the star should be spread out equally over the four central pixels. If you have counts between 2000 and 50000, with the background being set to 1000, things are fine. If the counts are too high, choosing a lower binning factor reduces the flux per pixel.

At the end of the **Store Corrected** sequence, two graphs with two curves each pop up. The first shows the center positions (in CCD pixel units) that should all be around zero, the second shows the Piezo commanded positions that have to be between -0.0001 and 0.0001. If the latter curve is a straight line at -0.0001 or 0.0001 that means that the corresponding Piezo has reached the limit of its throw. The star has to be repositioned in its subarray, by using the middle mouse button in **Movie** mode. One exits from this display by moving the mouse into the xterm window that was opened with the graphs and hitting the return key.

4. Tip-tilt ON and Tip-tilt + Focus ON

One can now guide on that star by clicking on **Tip-tilt ON.** To select tip-tilt and focus correction click **Tip-tilt + Focus ON**. The real-time image center coordinates are displayed in another salmon colored GUI (**auigui.dl**) that can be activated either by typing `aui` or by clicking on **aui** in one of the other *.dl windows.

In the **Tip-tilt ON** mode, the gain can be adjusted on-line, simply by moving the **Gain** slider in **astroCam.tcl**. The effect is quite obvious. A gain of 100 should be fine when the PZT drives are operated in closed loop mode. Overcritical (gain > 100) and undercritical (gain < 100) operational modes can improve tip-tilt correction.

5. Tip-tilt correction and chopping

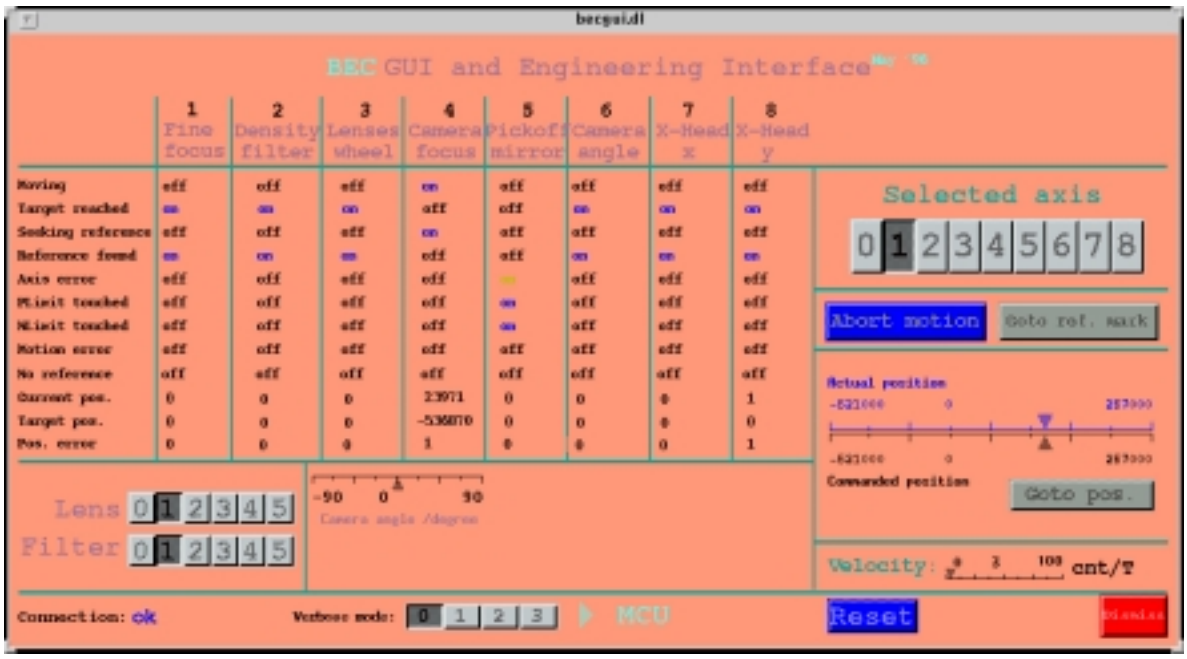
Click on the **Enabled/on** button below the **Chop modes** label in the **mcugui.dl** window. To select a chop angle and a chop throw move/change the sliders below the **Chopping** label. Find and select a star as described above.

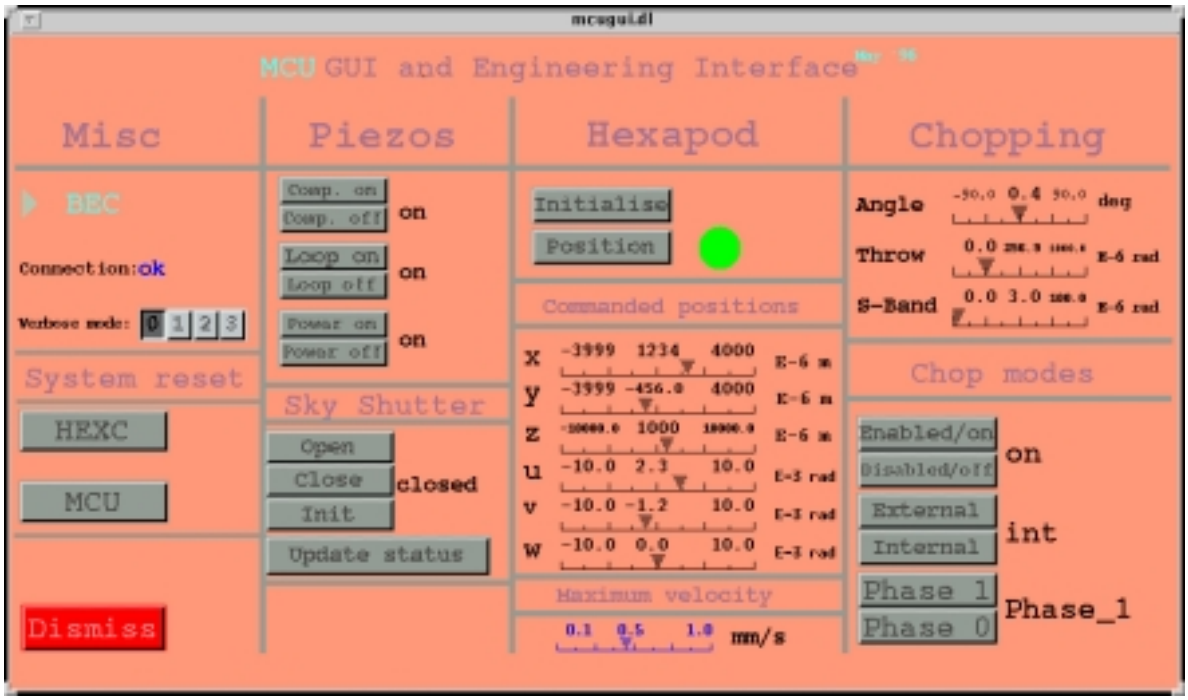
You have to (re)select a star as described above after modifying any of the chop parameters.

Press **Tip-tilt ON** or **Tip-tilt + Focus ON**.

Please note that whenever you change the **Chopping Angle** the **Camera angle** (check the **becgui.dl** window) changes so that a chop throw remains aligned with the orientation of a CCD (tip-tilt sensor) line.

6. Snapshots of becgui.dl and mcugui.dl





Chapter 3: Glossary

1. CCD parameters

The region of the CCD that is read out can be defined by **Full Frame, Full FOV, Subarray and Custom subarray**. The numbers on the left (**X-origin, Y-origin, X-width, Y-width, Custom subarray width** and **Binning**) give the detailed information. In **Full Frame, Full FOV** and **Subarray** mode, only **Binning** can be adjusted. In **Custom subarray** all parameters can be adjusted manually.

- **Full Frame** is the total visible area of the CCD.
- **Full FOV** is the part of the CCD where CHARM produces an image.
- **Subarray** is the default subarray for fastest readout.
- **Custom subarray** can be defined by the user either by typing the coordinates in the GUI or by using the left mouse button in **Acquisition** mode.

2. Gain

Gain is the factor (in %) of the measured image center position that is applied to the Piezos. 100% means that the Piezos attempt to put the measured center position to the center of the subarray. 80% means that the image center after correction is 20% of the measured value. Reducing the gain to values smaller than 100% provides some sort of damping and increasing the gain to values greater than 100% provides overcritical operation.

3. System status and Command status

Both provide information on these statii. Messages are **idle** and **busy**, and **sending command**, **ok**, **acceptTimeout** and **commandTimeout.**

4. Setup

Refresh CCD starts blinking after 60 minutes. Clicking on that button reinitializes the CCD. This takes about 20 seconds and removes all the charge that has accumulated in open shutter modes. It's a good idea to do it from time to time, but by no means vital.

5. Imaging modes

There are **Acquisition**, **Dark**, **Movie**, **Tip-tilt ON**, **Tip-tilt + Focus ON**, **Store Corrected**, **Store Uncorrected**, **Store Focus Corrected** and **Store Focus Uncorrected**.

- **Acquisition** takes one image and displays it. In this mode as well as in **Movie** mode the shutter is opened and closed, and the middle and the right mouse button can be used to move the star on the CCD. In addition to these features, one can define a custom subarray in **Acquisition** mode by clicking with the left mouse button on the desired center position of the subarray. Then, the **Custom subarry** is invoked automatically after exiting from the **Acquisition** mode by typing *q* inside the image.
- **Movie** is essentially the same as **Acquisition** except that it refreshes the image as fast as it can until typing *q* with the cursor in the image.
- **Dark** takes an 'image', but the shutter remains closed. This allows you to check the background.
- **Tip-tilt ON** (or **Tip-tilt + Focus ON**) starts the tip-tilt correction (and Focus correction) until clicking on
- **Stop LOOP.** At the end, the last subarray is displayed to make sure that guiding was done on a star and not on the sky background. If the system starts oscillating the **Gain** can be set to smaller values. In the **auigui.dl** window the centroids are displayed on-line.
- **Store (Focus) Corrected** takes a number of images specified in **Frames to store** and displays the centroid position as a graph (**gnuplot**) and, after hitting the return key with the cursor in the underlying window, the voltages sent to the Piezo as a graph. Hitting the return key again exits from this graph mode and the image displaying all the subarrays as a tile image. Here one can check the intensity in the single images.
- **Store (Focus) Uncorrected** does the same as above, except it doesn't correct and it doesn't display the voltages. Here, one can check in the tile image e.g. whether the star leaves the subarray.

6. Other business

The exposure time is set with exposure time. The loop frequency (the reciprocal of the sum of exposure time and readout time and overhead) is calculated automatically according to the position and the size of the subarray. Vice versa, one can choose the loop frequency and the exposure time will be set accordingly. One should always make sure that the read out time is at least 4-5 times shorter than the exposure time. Changing the binning changes the readout time and, thus, the loop frequency is adjusted accordingly.

7. Data files

Each **Imaging** (except **Movie**, **Tip-tilt** (**+ Focus**) **ON**) command creates a FITS data file with a filename defined in the **Options -> Save ...** menu. Each data file consists of a prefix and a 4 digit number, e.g. /work/tracker/data/Aug96/test**0000.**

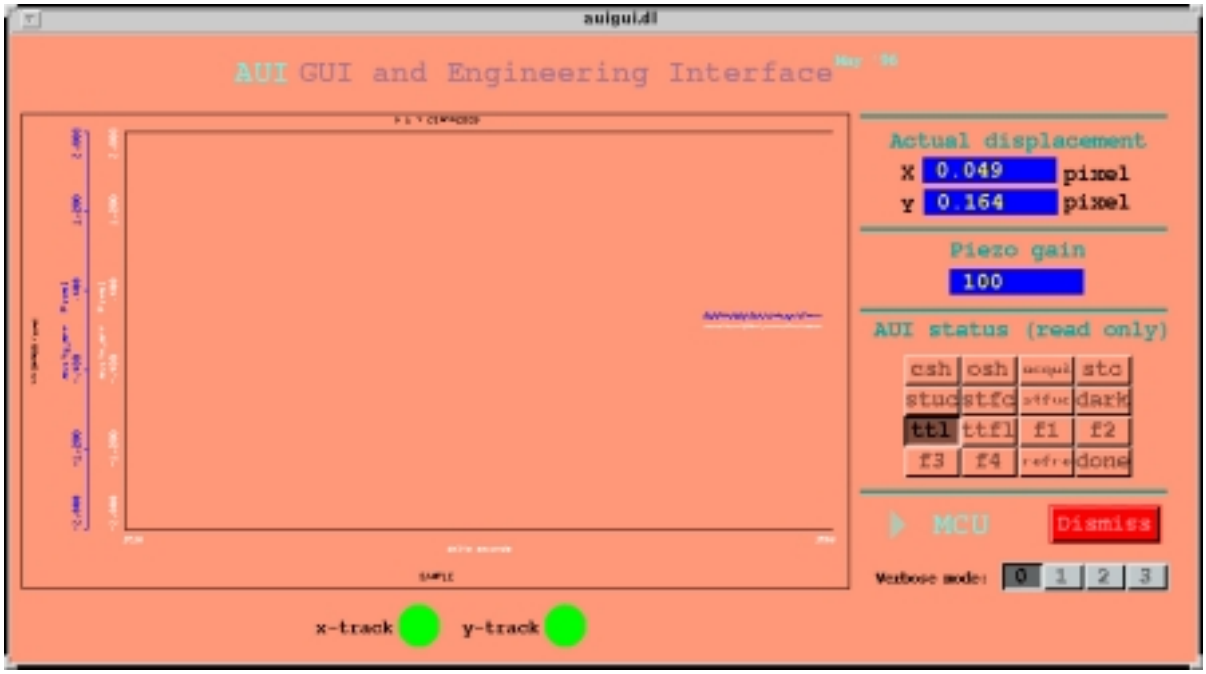
In your working directory ($WROOT) a symbolic link LAST.fits points to the last image taken.

Movie creates a FITS data file **movie.fits** in $WROOT.

Tip-tilt (**+ Focus**) **ON** creates a FITS data file **doTipTilt.fits** in $WROOT.

All **Store ... (Un)corrected** commands create an additional table file ready to plot with **gnuplot**, e.g.
`gnuplot storeAllCorr.gpl` or `gnuplot storeAllUncorr.gpl`.
The table file name is created by adding **.centroid4** to the FITS data file name.

8. Snapshot of auigui.dl



Chapter 4: What to do when ...

1. Questions and answers about using the MPIA-UKIRT-Project software

How can I reboot the AstroCam camera?
Open the VME/VxWorks console or window and give:

`cd "/ASTROMED/42gci"` then type
`vx42gci("new")` and finally type
`aui("b016link","setor","2")`

How can I log (save to a file) all these Info (*verbose mode 1*) or Debug (*verbose mode 2*) messages when I activate *Verbose mode 3* (Info and Debug messages) in one of the *.dl windows?
Open an xterm window on your workstation. From this xterm window open a telnet session to the VME/VxWorks system. Hold down the <Ctrl>-key and the left mouse button and select **Log to File** from the **Main Options** menu that pops up.

The AstroCam system does not boot. How can I check the transputer communication?
Type the command **inmosCheck** on the VME/VxWorks console. If the output doesn't look like the one below you probably have a hardware or cabling problem**.**

Using /bxvi00 inmosCheck 3.0

```
# Part rate Mb Bt  [  Link0  Link1  Link2  Link3 ]
0 T16  -20 1.75 1  [    1:0  HOST    ...    ...  ]
1 T2    -20 1.20 0   [    0:0    ...    ...     ...  ]
```

How can I log (save to a file *mcu.log*) status information of the *mcu* subsystem?
Open the VME/VxWorks console and give*:* `mcuSysStatusAll(1) > mcu.log`

How can I log (save to a file bec.log) status information of the *bec* subsystem?
Open the VME/VxWorks console and give*:* `becSysStatusAll(0,1) > bec.log`

Is there an easy way to move a star on the Tip-tilt sensor via the crosshead?
Select **Full FOV** and start **Movie** in **astroCam.tcl.** When the image display pops up click with the middle mouse button on a star, move the pointer to the "new" position inside the image display and click the middle mouse button again. The star will move the last "clicked" position.